Development of Shared InTentions and Cooperation in a Humanoid Robot via Situated SIMulation Models - SITSIM

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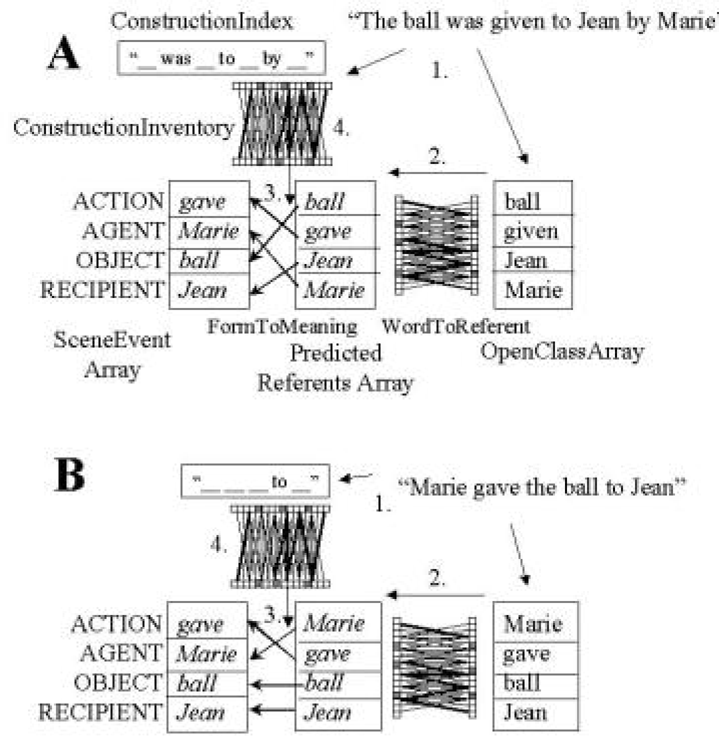
Project Overview: The Goal – A Cooperative Humanoid

- Vision and Language for action understanding
- Composition of action/language primitives for spoken language programming
- Vision, action and language
- Shared Intentions
- Situtated simulations for embodied cognition

Grounded Sentence Learning

- Training corpus:
  - ~300 sentence-scene pairs generated
  - 10 Construction types
    - Active, dative, passive, relative ….
- “Developmental” Learning Trajectory
  - Simple SVO structure with full vocabulary
  - Then add datives, passives and relatives
- Why?
  - Learning new constructions requires that the constituent open class words are well-known so the appropriate mappings can be established



Dominey (2003) CogSci, Dominey, Boucher (2005) Artificial Intelligence

Spoken Language for Composing primitives into behaviors

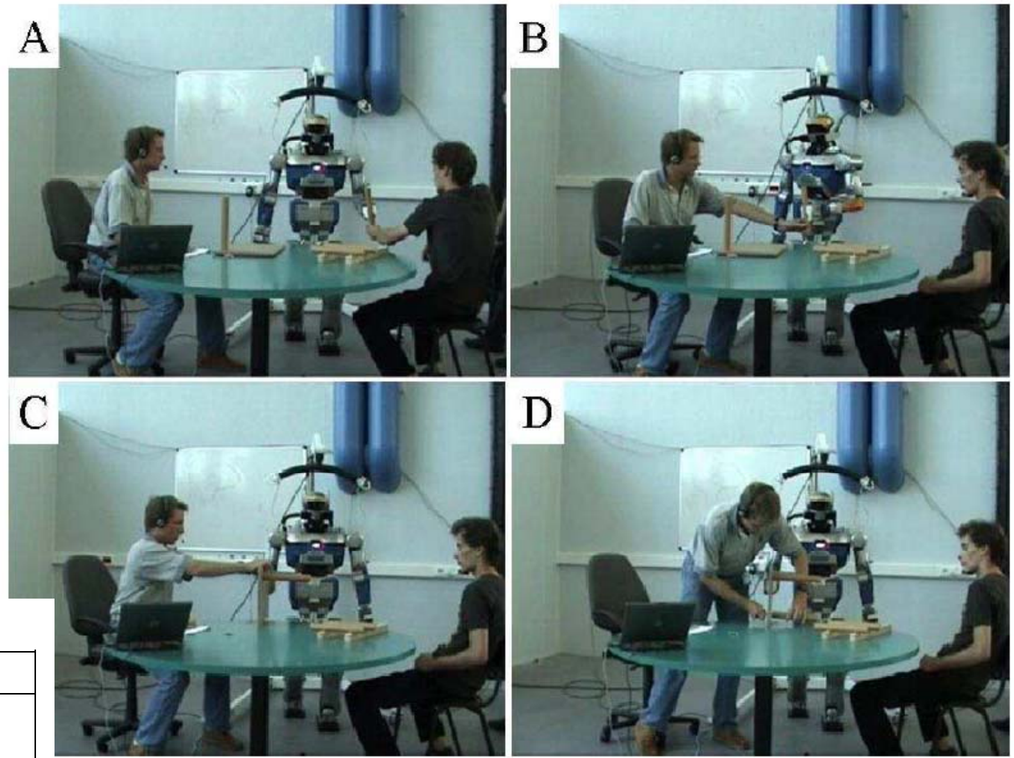


Table 1. Action Commands

Motor Command	Resulting Actions
Prepare	Move both arms to neutral position, rotate chest to center, elevate left arm, avoiding contact with the work surface (5 DOF)
OpenLeft	Open left hand (1 DOF)
CloseLeft	Close left hand (1 DOF)
Give it to me	Rotate hip to pass the object in left hand to user on the right (1 DOF)
Hold	Center hip, raise right arm preparing to hold table top (5 DOF)
Right open	Open right hand (1 DOF)
Right close	Close right hand (1 DOF)

Table 2. Learning and Control Commands

Commands	Correspondence
Learn	Begin encoding subsequent commands
OK	Store encoded command sequence in macro
Macro	Execute the stored macro
Wait	Interrupt command execution until a spoken "continue" command is issued
Continue	Terminate the "wait" pause and resume execution.

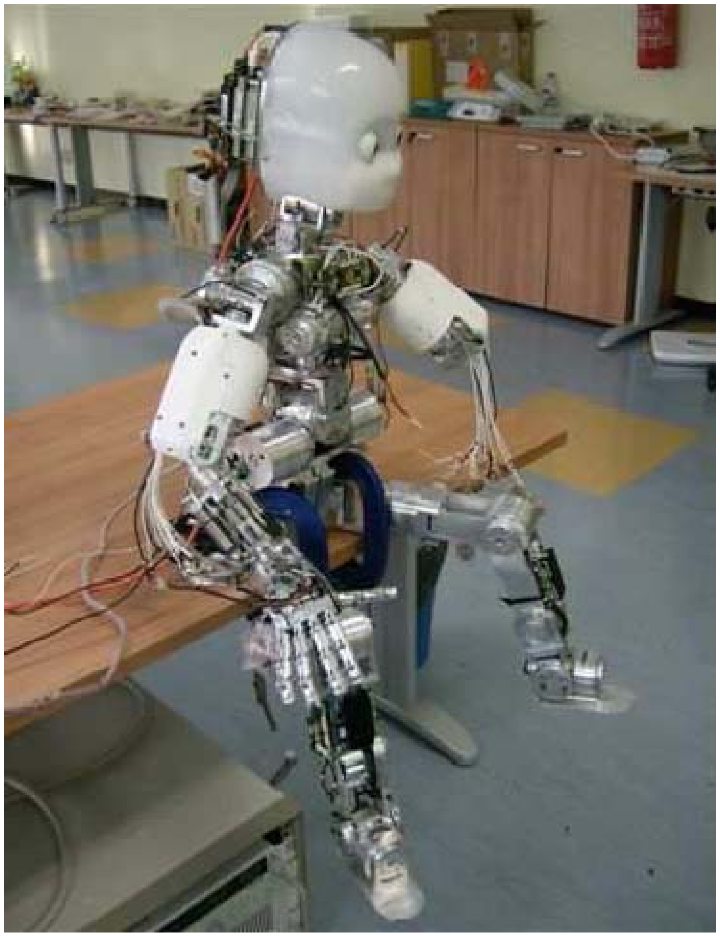
Part of Joint Robotics Laboratory project, CNRS LAAS Toulouse,

Dominey, Mallet, Yoshida (2007) IEEE Int. Conf. Robotics & Automation 2007

Teaching a Generalized Sensorimotor Behavior

- Give me the green leg
- Training with one example
  - *Green* is passed as an argument to TAKE
  - Learned procedure generalizes over (yellow, rose, green, orange)
  - Powerful learning capability with procedures that take variables
- Embodiment of lexical categories
  - Verbs – procedures
  - Nouns – arguments
- Requires more sophisticated skills
  - Vision
  - Inverse kinematics

Part of Joint Robotics Laboratory project, CNRS LAAS Toulouse,
Dominey, Mallet, Yoshida (2007) IEEE Int. Conf. On Humanoid Robotics



RobotCub

iCub

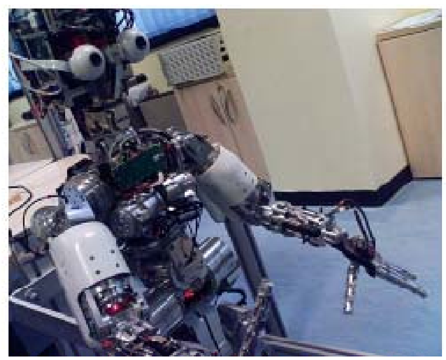
Cognitive Humanoid Robot

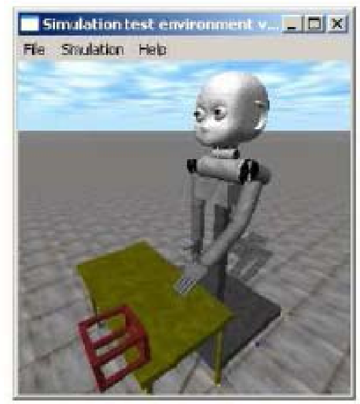
Research Platform

Cogsys
Cognitive Systems.eu

Proposal Title:

Development of Shared InTentions and Cooperation in a Humanoid Robot via Situated SIMulation Models (SitSim)





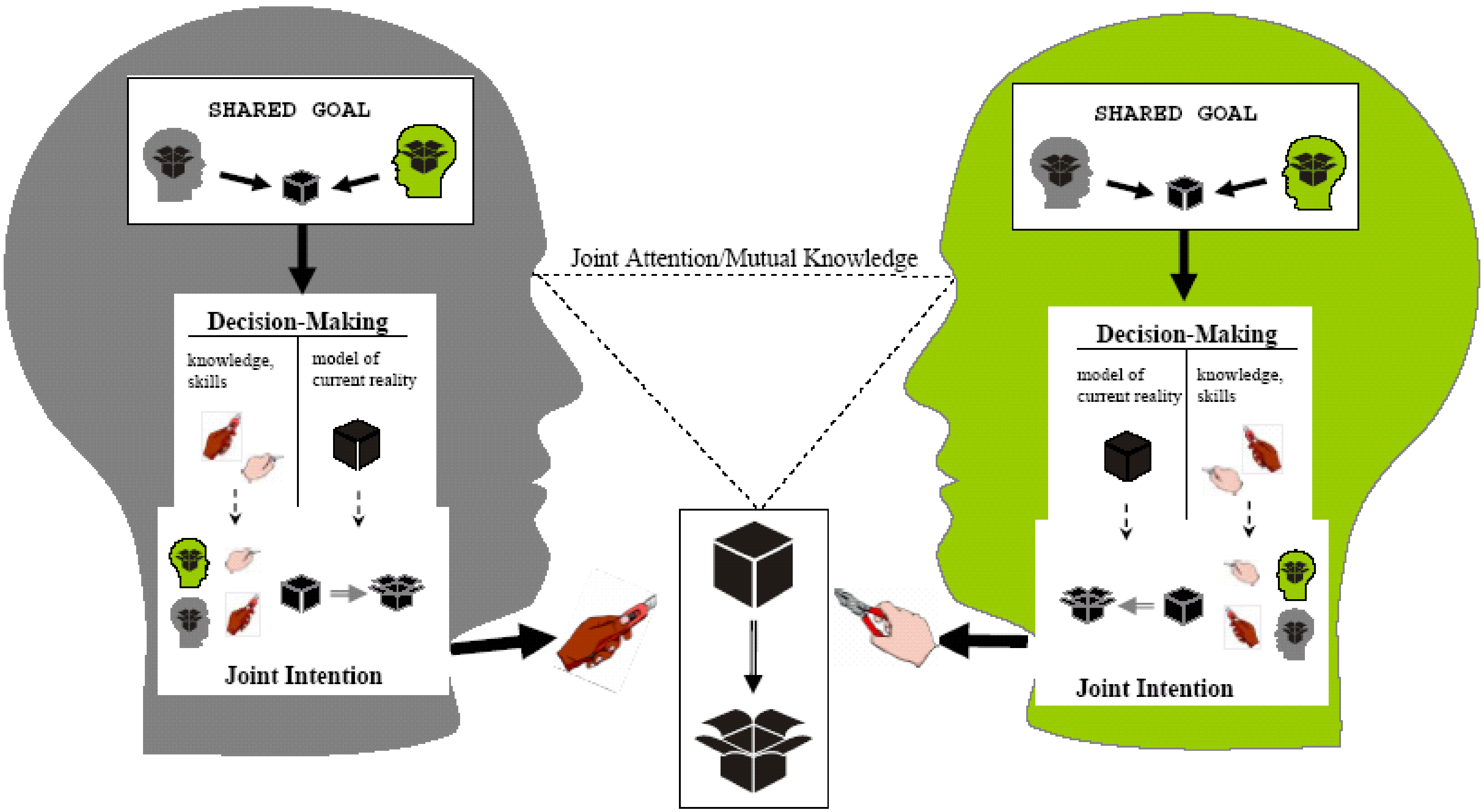
Parallel control of iCub and ODE simulator by spoken language during a preliminary proof of concept test at IIT, Nov 21, 2007

Automatic Learning, and Anticipation

- On-line Learning of complex cooperative behavior via continuous interaction history monitoring
- Yeilds Aniticpation for
  - Speech recognition
  - Action propositions
  - Action Inititiatve taking

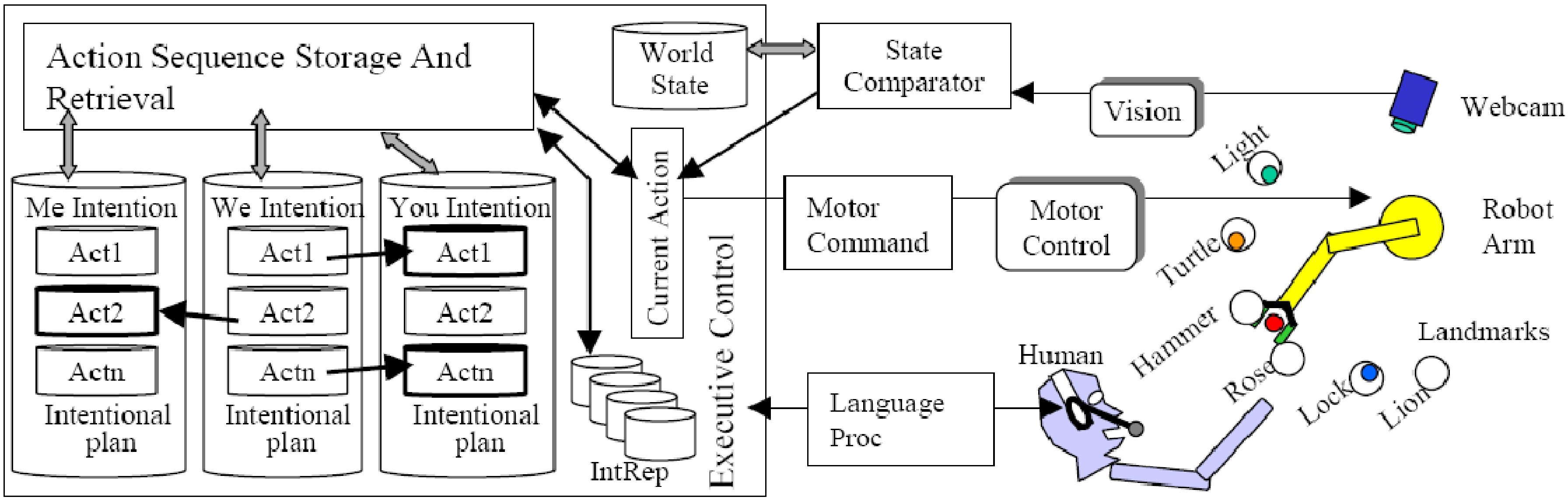
Dominey, Metta, Nori, Natale (2008) IEEE Int. Conf. On Humanoid Robotics

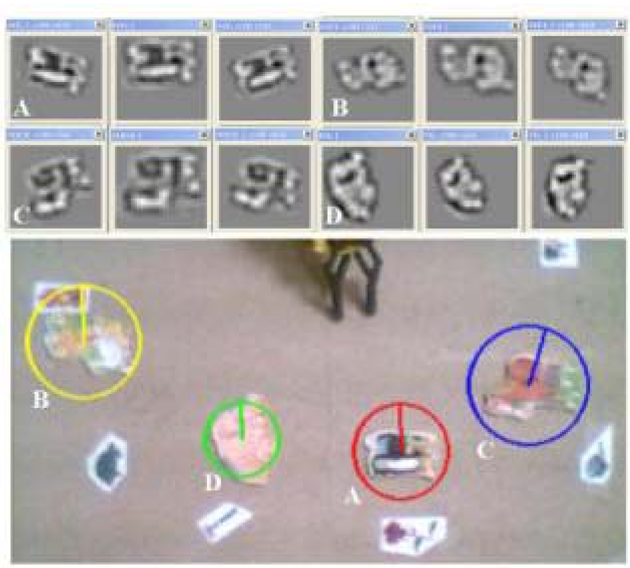
Shared Intentions & Situated Simulations



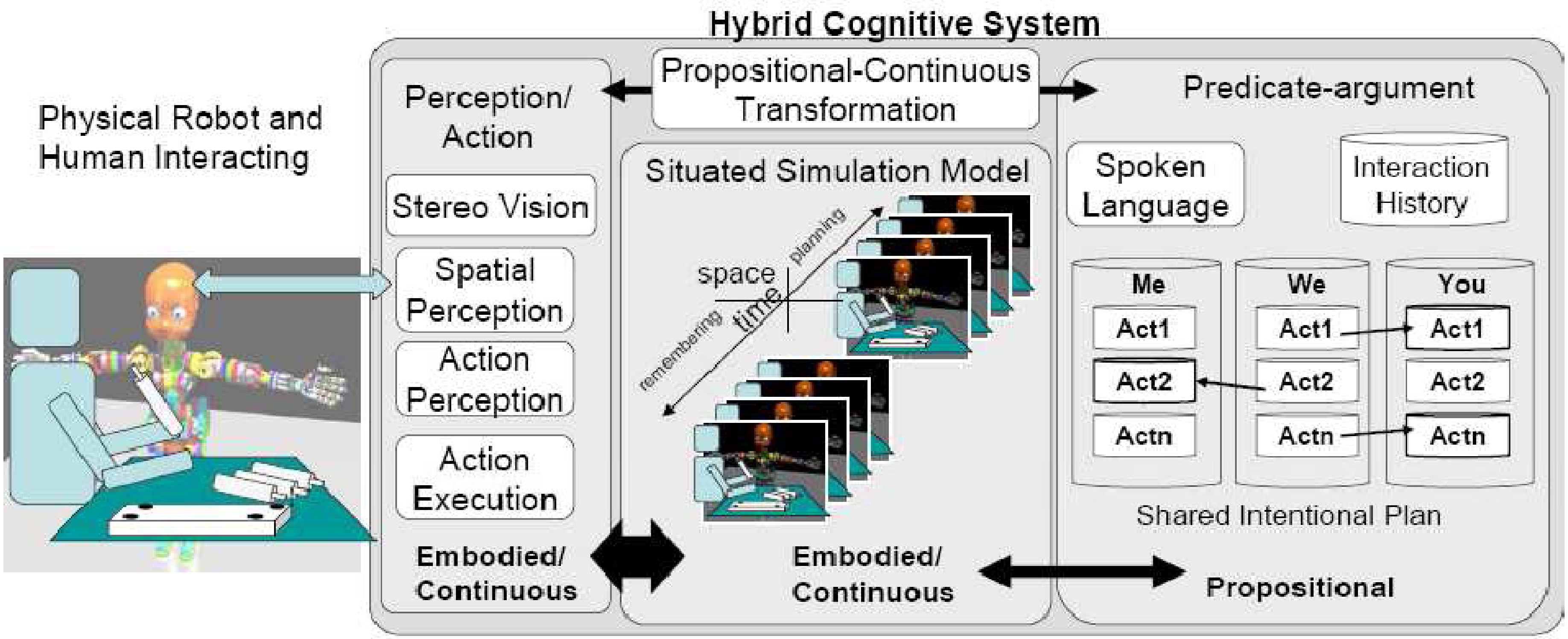
Tomasello et al. Behavioral and Brain Sciences, 2005

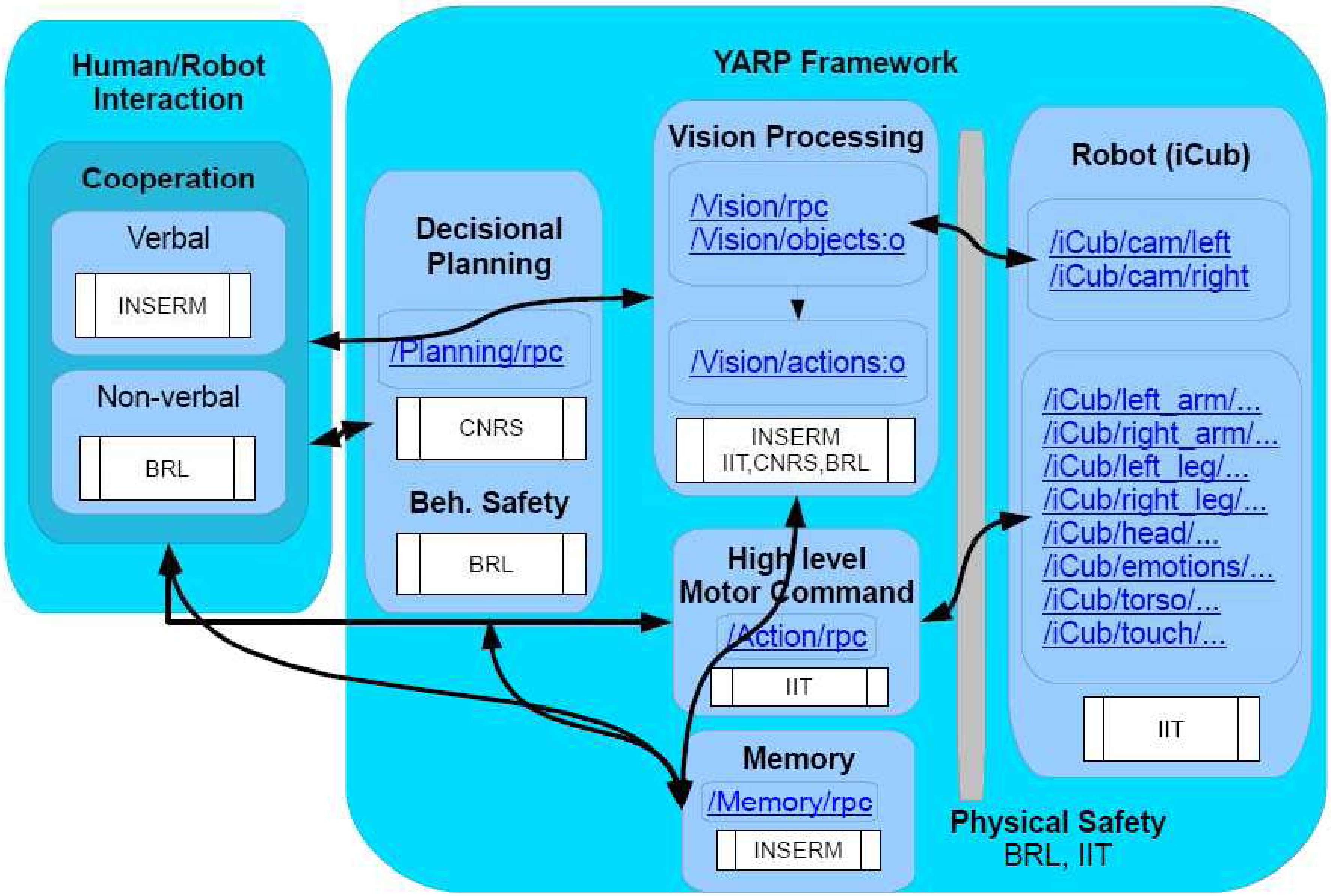
Implementing Shared Plans





Situated Simulation Architecture

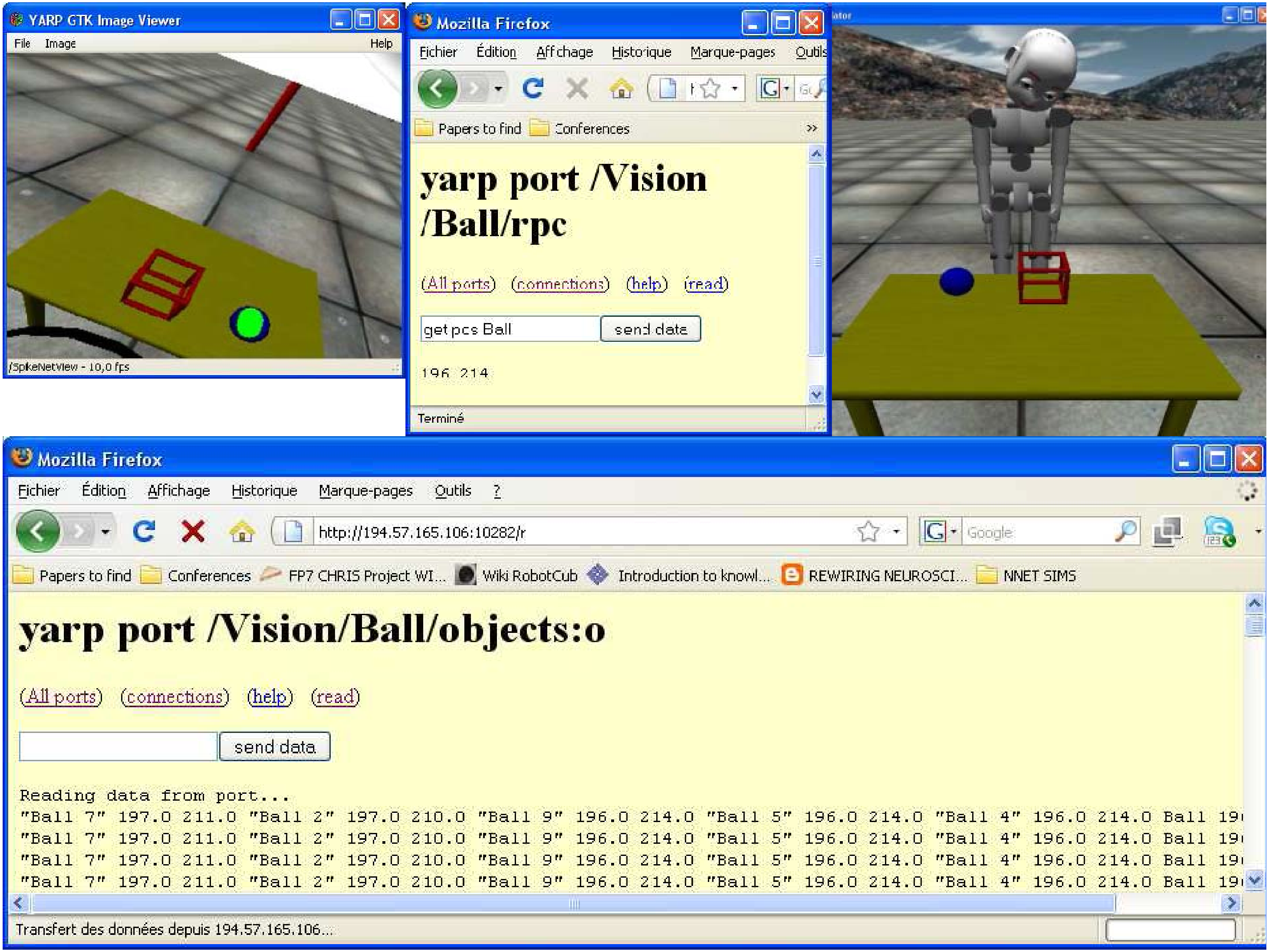




Human/Robot Interaction
Cooperation
Verbal
INSERM
Non-verbal
BRL
YARP Framework
Decisional Planning
/Planning/rpc
CNRS
Beh. Safety
BRL
Vision Processing
/Vision/rpc
/Vision/objects:o
/Vision/actions:o
INSERM
IIT,CNRS,BRL
High level Motor Command
/Action/rpc
IIT
Memory
/Memory/rpc
INSERM
Robot (iCub)
/iCub/cam/left
/iCub/cam/right
/iCub/left_arm/...
/iCub/right_arm/...
/iCub/left_leg/...
/iCub/right_leg/...
/iCub/head/...
/iCub/emotions/...
/iCub/torso/...
/iCub/touch/...
IIT
Physical Safety
BRL, IIT

Spikenet Vision

http://www.spikenet-technology.com/


YARP GTK Image Viewer
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yarp port /Vision/Ball/objects:o
(All ports) (connections) (help) (read)
send data
Reading data from port...
"Ball 7" 197.0 211.0 "Ball 2" 197.0 210.0 "Ball 9" 196.0 214.0 "Ball 5" 196.0 214.0 "Ball 4" 196.0 214.0 Ball 19
"Ball 7" 197.0 211.0 "Ball 2" 197.0 210.0 "Ball 9" 196.0 214.0 "Ball 5" 196.0 214.0 "Ball 4" 196.0 214.0 Ball 19
"Ball 7" 197.0 211.0 "Ball 2" 197.0 210.0 "Ball 9" 196.0 214.0 "Ball 5" 196.0 214.0 "Ball 4" 196.0 214.0 Ball 19
"Ball 7" 197.0 211.0 "Ball 2" 197.0 210.0 "Ball 9" 196.0 214.0 "Ball 5" 196.0 214.0 "Ball 4" 196.0 214.0 Ball 19
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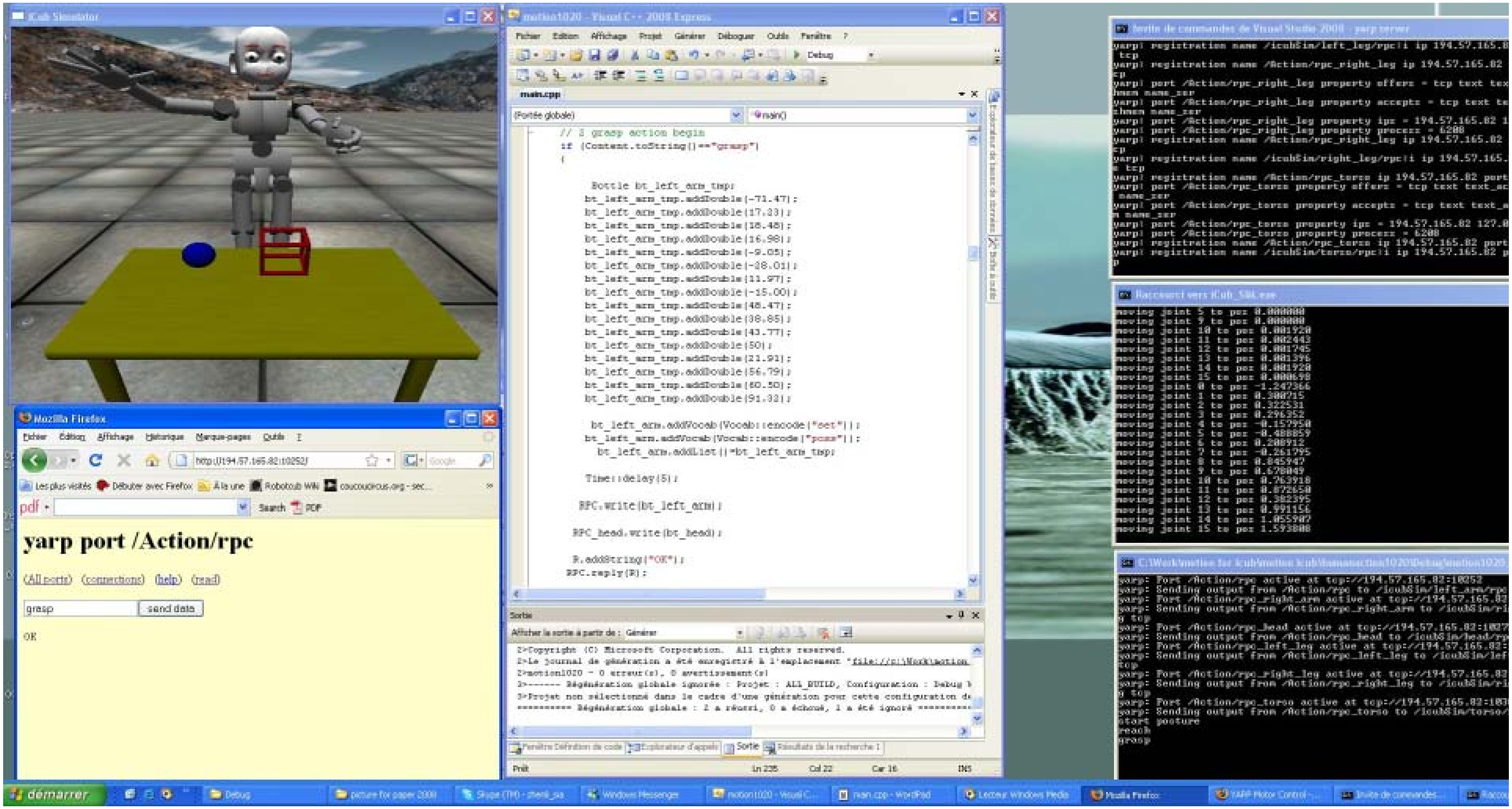
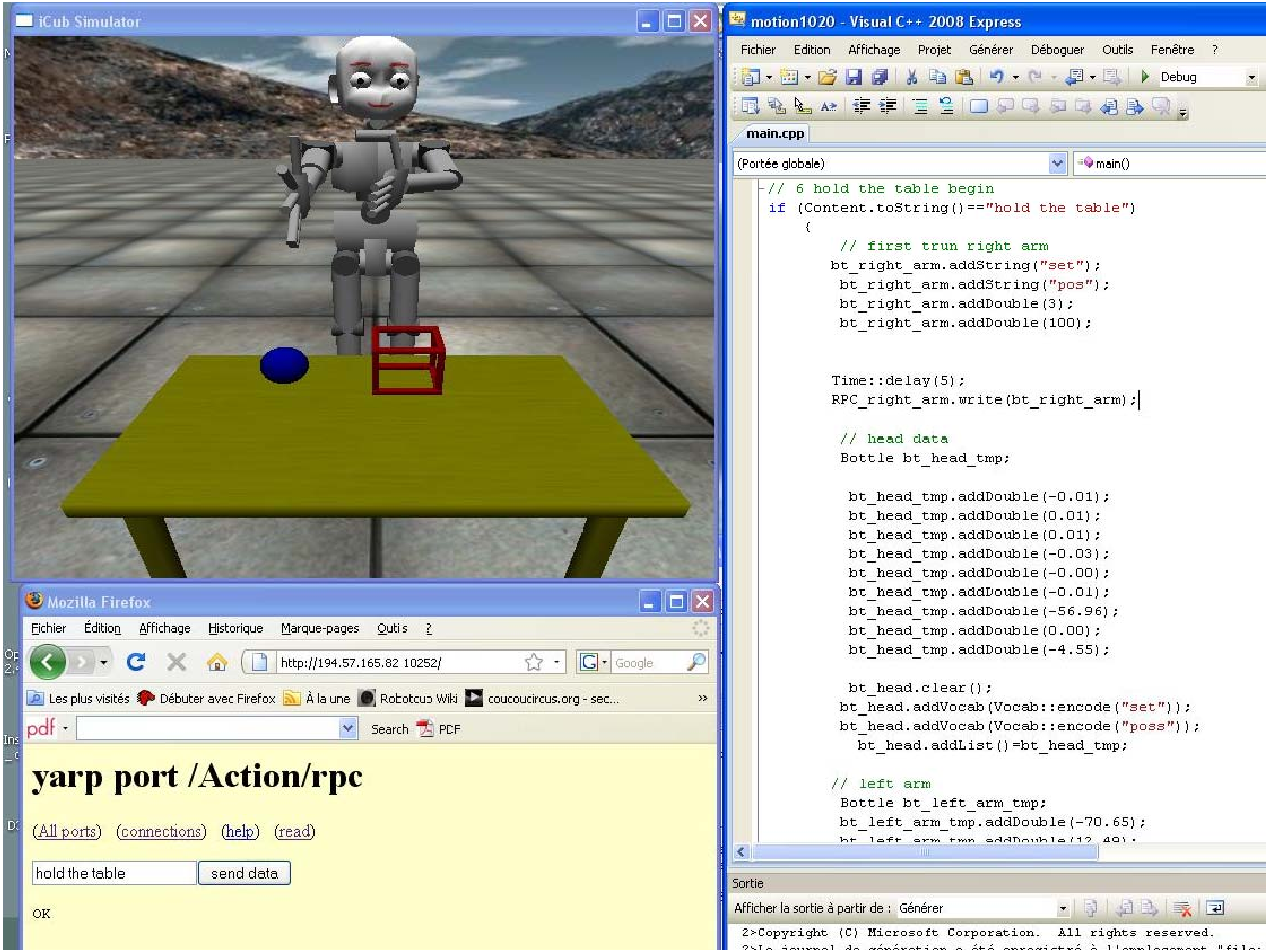

iCub Simulator
motion1020 - Visual C++ 2008 Express
main.cpp
// 2 grasp action begin
if (Content.toString()=="grasp")
Bottle bt_left_arm_tmp;
bt_left_arm.addVocab(Vocab::encode("set"));
bt_left_arm.addVocab(Vocab::encode("poss"));
bt_left_arm.addList()=bt_left_arm_tmp;
Time::delay(5);
RPC.write(bt_left_arm);
RPC_head.write(bt_head);
R.addString("OK");
RPC.reply(R);
Mozilla Firefox
yarp port /Action/rpc
(All ports) (connections) (help) (read)
grasp
send data
OK
démarrer


iCub Simulator
motion1020 - Visual C++ 2008 Express
Fichier Edition Affichage Projet Générer Déboguer Outils Fenêtre ?
Debug
main.cpp
(Portée globale)
main()
// 6 hold the table begin
if (Content.toString()=="hold the table")
{
// first trun right arm
bt_right_arm.addString("set");
bt_right_arm.addString("pos");
bt_right_arm.addDouble(3);
bt_right_arm.addDouble(100);
Time::delay(5);
RPC_right_arm.write(bt_right_arm);
// head data
Bottle bt_head_tmp;
bt_head_tmp.addDouble(-0.01);
bt_head_tmp.addDouble(0.01);
bt_head_tmp.addDouble(0.01);
bt_head_tmp.addDouble(-0.03);
bt_head_tmp.addDouble(-0.00);
bt_head_tmp.addDouble(-0.01);
bt_head_tmp.addDouble(-56.96);
bt_head_tmp.addDouble(0.00);
bt_head_tmp.addDouble(-4.55);
bt_head.clear();
bt_head.addVocab(Vocab::encode("set"));
bt_head.addVocab(Vocab::encode("poss"));
bt_head.addList()=bt_head_tmp;
// left arm
Bottle bt_left_arm_tmp;
bt_left_arm_tmp.addDouble(-70.65);
Sortie
Afficher la sortie à partir de : Générer
2>Copyright (C) Microsoft Corporation. All rights reserved.
Mozilla Firefox
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http://194.57.165.82:10252/
Google
Les plus visités Débuter avec Firefox À la une Robotcub Wiki coucoucircus.org - sec...
pdf Search PDF
yarp port /Action/rpc
(All ports) (connections) (help) (read)
hold the table
send data
OK

SSM and Language

- Perform experiments to demonstrate the usefulness of the SSM that cannot be provided by a purely propositional system. For example, in the table scenario, the SSM should allow the robot to (a) reconstruct visuospatial perceptual scenes from memory and answer questions about them (extending Roy 2004, Mavridis & Roy 2006), and (b) to use the SSM to predict and simulate future events to determine if a specific plan is feasible or not, interacting with the operator via spoken language.

SSM and Meaning

- We will enhance the baseline shared planning capability to further exploit the SSM in order to associate the action outcomes (state changes) to the unfolding shared plan (Gorniak & Roy 2007, Boucher 2006ab). This will provide a form of “meaning” including a true shared goal, allowing the robot to help the user in *novel* situations (Warneken 2006a,b) based on knowledge of the goal. We will likewise address how temporal, spatial and causal structure can be extracted from Situated Simulations (Mavridis & Roy 2006).

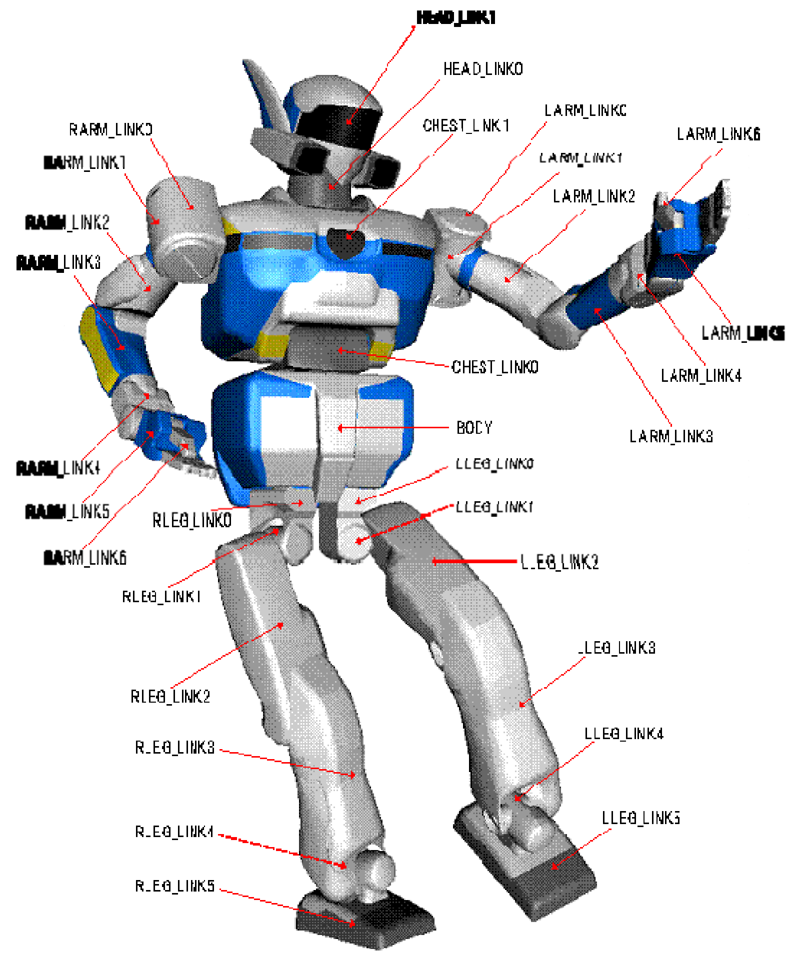
The Scientific Team

- **INSERM Team**
  - Peter Ford Dominey
  - Michel Hoen
  - Carrol Madden
  - Jocelyne Ventre-Dominey
  - Jean-David Boucher
- **External Collaborators:**
  - Felix Warneken, Researcher, Max Planck Institute for Evolutionary Anthropology – Development of Shared Intentions
  - Rolf Zwaan, Professor, Erasmus University - Embodied Cognition, Situated Simulation, Language
- **External Advisors:**
  - Lawrence W. Barsalou, Professor, Emory University – Embodied Cognition and Situated Simulation
  - Deb Roy, Professor, MIT – Cognitive Robotics, Robotic Mental Imagery

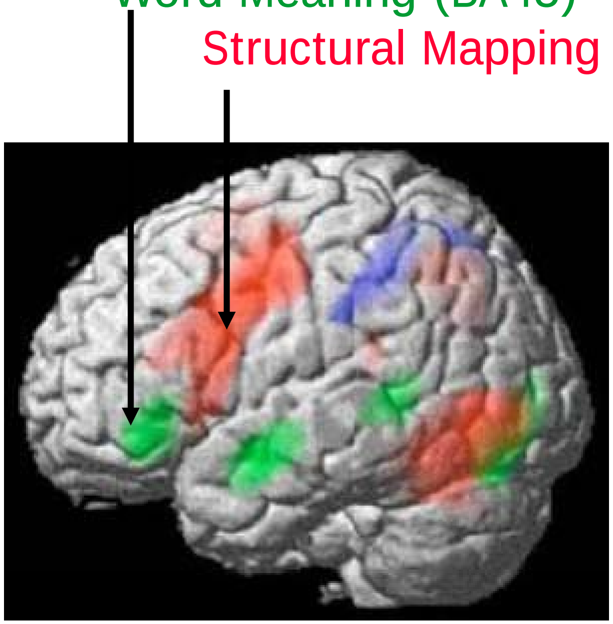
- FP7 ICT Project ‘Cooperative Human Robot Interaction Systems’ CHRIS
  - Post Doc and PhD
- French FP7

Human-Robot Cooperation is a **difficult problem** – how can we address it?

- Look to the experts – humans
- Look at the brain

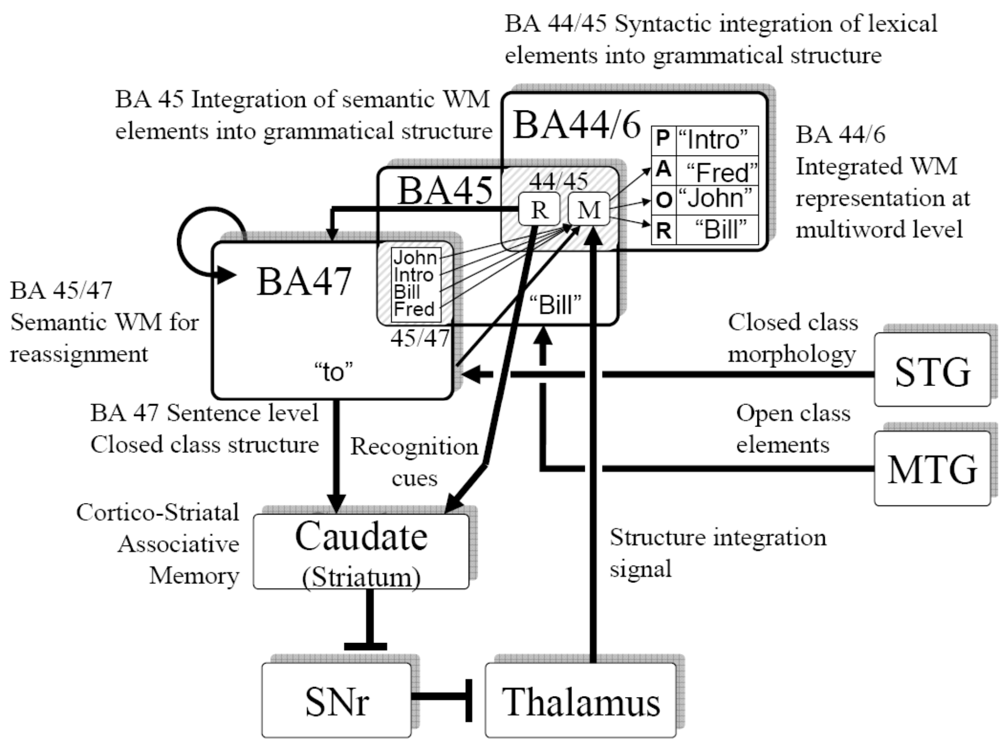


What Can the Brain tell us about Human-Robot Interaction?



Human sentence processing
fMRI Study

(Hoen, Dominey et al. Cortex, 2006)



(Dominey, Hoen, Inu, Journal of Cognitive Neuroscience 2006
Dominey, Inui, Hoen, Brain and Language 2008)

What the brain (and humans) can tell us about human-robot interaction

- Language allows
  - The specification of procedure calls, with arguments – it is a link to action
    - “You give John the leg” is mapped onto the command:
    - Give(Robot, John, leg)
  - ‘Meta’ control of the interaction
    - Learn a new behavior!
    - Wait for my signal!
    - Let’s change roles!
    - …
  - A Shared-Joint representation of the collaborative work between human and robot is central

A Theoretical Context: The Robot Apprentice

- The robot should have:
  - Some Basic Skills
  - Ability to Learn from the Expert
  - Ability to use language to guide action, including learning
  - Notion of Shared Plans

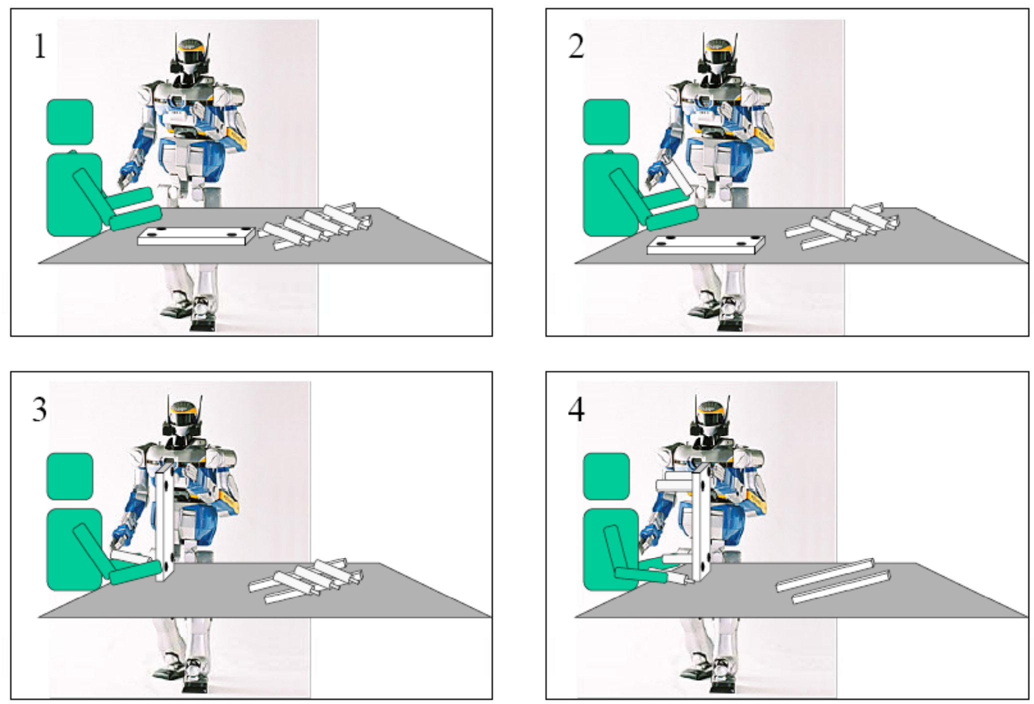


Table-Building Scenario

Lessons Learned

Good news

- Small set of primitives
  - Works for assembly
  - Generalizes to disassembly!
- Allows human and robot to interact

Bad news

- Sequences are ‘rigid’
- No perception involved
- Does not generalize

What next?

- What is generalization?
- Operation over an ‘equivalance class’
  - Learn with one example of the class
  - Extend to all member

Lessons Learned

Good news

- Perception over a class of objects
- Allows generaliztion to objects in that class
- More complex grammatical constructions
  - Action(agent, object, recipient)

Bad news

- Learning is not automatic

What next?

- Autonomous learning
- Different levels of knowledge application

Lessons Learned

Good news

- Autonomous learning
- Fluid interaction

Bad news

- Robot does not "know" what a table is. It does not know about the goal

What next?

- Introduce meaning as "situated simulations"

What can we do now?

- Thanks
- Questions?
- Collaborations?

Future cooperation

- Working to develop a platform independant interaction capability
- Define primitives
- Compose into complex behaviors
- Robot takes different levels initiative
- Use language as action

Language as Action

- A Language/Action Perspective on the Design of Cooperative Work
- Terry Winograd
- ***people act through language***